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PROCEEDINGS

On the Fatigue Crack Initiation in Metallic Sealing Rings: From Manufacture to Service

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ABSTRACT

Metallic sealing rings made from nickel-based superalloys are critical components of aero engines that prevent the leakage of high-pressure liquid or gas fuel. As one of the main failure modes, fatigue cracking has been a concern for the aerospace industries because the formation of even a micro-crack may cause an aviation accident. For the purpose of manufacturing fatigue-resisting sealing rings, much effort has been spent on the lifetime predicting under fatigue loadings. However, the fatigue analysis of metallic sealing rings is challenging due to several aspects. On the one hand, the diameter of the rings (>100mm) is orders of magnitude higher than the geometrical characteristics of its cross-section (<1mm), the deformation history, especially the stress distribution from manufacture to service, is very complex and varies with the forming procedure and in-service conditions. On the other hand, the fatigue crack initiation in superalloys is extremely microstructural-sensitive. Hence, the crack prediction must be considered at both component-scale and microstructure-scale. In this study, a macroscopic finite element (FE) model has been established to investigate the deformation history from forming W-shaped rings to service under multiple fatigue conditions. The stress status at critical regions, e.g., the crest and trough of the W-ring, was extracted and applied as the boundary conditions in a microstructure-based crystal plasticity (CP) model. The fatigue lives of the component under different forming processes and service conditions were estimated based on the local stored energy evolution in the CP model. The threshold of stored energy for fatigue crack initiation was determined by integrating three-point bending experiments and the corresponding FE and CP analysis. The conclusions of this work can provide theoretical guidance for the manufacturing of high-performance metallic sealing rings.

KEYWORDS

Rolling forming; W-shaped metallic sealing rings; muti-scale modeling

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